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Trinity Consultants

VIA E-MAIL: mohr.ashley@epa.gov

September 28, 2018

Ms. Ashley Mohr
Permit/SIP Modeling
USEPA Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202

RE: TGTI DWP Application - Supplemental Air Quality Analysis Information

Dear Ms. Mohr:

This letter provides supplemental Air Quality Analysis (AQA) information in support of the Deepwater Port (DWP) license application for the proposed Texas Gulf Terminals Inc. (TGTI) Single Point Mooring (SPM) operation.

NUSTAR PHOTOCHEMICAL MODELING REPORT

Attachment 1 to this letter includes a copy of the NuStar photochemical modeling report prepared in December 2011. As shown on Page 22 of the modeling report, the NuStar project had an annual VOC emissions rate of 1,104 tpy, and a maximum increase of 0.18 ppb related to the 8-hr ozone concentration within the urban airshed per the 2011 photochemical model. These values are also referenced in Appendix C, Page 7-2 of TGTI's air quality analysis for the July 2018 DWP license application. As such, the increase in ozone concentration from the proposed operations and TGTI's SPM terminal are expected to be approximately 2 ppb. When compared with the 8-hour ozone standard of 70 ppb, and a 2015-2017 background concentration (discussed further in this letter) of 62.33 ppb, the incremental increase in ozone from the proposed project is below the threshold.

REPRESENTATIVE BACKGROUND OZONE CONCENTRATIONS

Section 8.3.2.b of 82 Federal Register (FR) 5221, January 17, 2017 states "*The EPA recommends use of the most recent quality assured air quality monitoring data collected in the vicinity of the source to determine the background concentration for the averaging times of concern. In most cases, the EPA recommends using data from the monitor closest to and upwind of the project area. If several monitors are available, preference should be given to the monitor with characteristics that are most similar to the project area. If there are no monitors located in the vicinity of the new or modifying source, a ''regional site'' may be used to determine background concentrations. A regional site is one that is located away from the area of interest but is impacted by similar or adequately representative sources.... "*

TGTI has utilized this guidance from EPA in choosing a representative background monitor. The onshore TGTI Tank Farm will be located in Nueces County. The proposed Booster Station and Valve Station will be located in Kleberg County and the SPM will be over 14 miles offshore from Kleberg County. Kleberg and Nueces Counties are designated as attainment or unclassifiable for all NAAQS. Based on a review of available TCEQ monitors[1], there are no ozone monitors in Kleberg County. In Appendix C, Section 7 of TGTI's air quality analysis submittal to EPA Region 6, Trinity utilized the ozone background concentration value from the Corpus Christ West Monitor. The 3-year average design value utilized in the ozone impact analysis (64 ppb) was from 2014-2016 obtained from EPA's air quality data – monitor values website[2]. The Corpus Christi West Monitor (Site ID 483550025) is in Neuces County. There are a total of nine (9) monitors in Neuces County (including Corpus Christi West). Only four (4) of those sites monitor ozone. These sites are included in the following table.

Site ID	Site Name	Distance to Onshore Storage Farm[3] (miles)
483550025	Corpus Christi West	12.12
483550026	Corpus Christi Tuloso	18.57
483550660	Holly Road	7.80
483550664	Violet	16.79

The following image shows the relative locations of the TGTI tank farm compared to the other ozone monitors.

[1] http://www17.tceq.texas.gov/tamis/index.cfm

[2] https://www.epa.gov/outdoor-air-quality-data/monitor-values-report

[3] The onshore tank farm is located at the following lat, long coordinates – 27.590843, -97.417691

As shown in the image, the Holly Road monitor is slightly closer in distance to the TGTI SPM terminal compared to the Corpus Christi West monitor (27.5 miles vs 32 miles). However, the two monitors are comparatively much closer to each other (approximately 4.5 miles). As a result, the corresponding difference in distance between the SPM terminal and the respective monitors is negligible. Therefore, TGTI has considered both monitors for representativeness to evaluate the appropriate ozone background concentration for the SPM terminal.

The Corpus Christi West monitor is located in an area that has significantly higher industrial density compared to the Holly Road monitor and the TGTI Tank Farm. Accordingly, TGTI believes the Corpus Christi West monitor is the most conservative option for selecting an ozone background concentration monitor for this project.

Below is a summary of the comparisons demonstrating representativeness between the Corpus Christi Monitor and the TGTI operations:

- The proposed TGTI Tank Farm is located in Nueces County and the Booster Station, Valve Station and offshore SPM are in or offshore of Kleberg County. All operations are in the same region (central U.S.), state (Texas), and vicinity as Neuces County;
- The annual average temperature for both counties is 72 °F (based on the closest major city);
- The maximum temperature for the year is also the same at approximately 94.2 °F;
- Neuces County and Kleberg County have similar terrain, both are located in south Texas bordering the Gulf of Mexico;
- Though greater in number, Neuces County consists of similar regional emission sources of pollutants as Kleberg County due to the same type of industry such as chemical, oil and gas, construction, etc.

A 2014-2016 background design value for ozone was previously provided in support of the TGTI DWP license application air quality analysis. TGTI is updating the design value based on 2015-2017 data for the Corpus Christi West Monitor.

Year	Background Concentration ppb	3-year ppb
2015	65	62.33
2016	62	
2017	60	

As shown above, the 3-year average for the Corpus Christi West monitor from the 2015-2017 timeframe is 62.33 ppb is lower than the 2014-2016 design value of 64 ppb. Therefore, the current ozone impacts analysis by TGTI adds additional conservatism regarding the design value for the ozone background concentration.

If you have any questions, comments, or need additional information, do not hesitate to contact Denise Rogers at (832) 203-6493, Shreyas Erapalli at (504) 828-5845, ext. 1003, or me at (972) 661-8100.

Sincerely,

TRINITY CONSULTANTS

Brian Burdorf

Brian Burdorf
Director

cc: Denise Rogers, Compliance Manager – TGTI
Shreyas Erapalli - Trinity Consultants

ATTACHMENT 1

NuStar Photochemical Modeling Report

HEADQUARTERS >
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North America | Europe | Middle East | Asia

Final Report

Evaluation of Ozone Air Quality Impact from NuStar Logistics, LP's Corpus Christi Terminal Operations

College of Engineering
University of North Texas
Denton, TX 76207

December 2011

Final Report
Evaluation of Ozone Air Quality Impact from
NuStar Logistics, LP's Corpus Christi Terminal Operations

Prepared for
NuStar Logistics, LP
410 SPID, Suite 200
Corpus Christi, TX 78405

Prepared by

Principal Investigator
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Dr. Zuber Farooqui

Department of Mechanical and Energy Engineering
College of Engineering
University of North Texas
3940 N Elm
Denton, TX 76207

December 2011

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Acronyms and Abbreviations

CAMx	Comprehensive Air Quality Model with extensions
CAMS	Continuous Air Monitoring Stations
CCUA	Corpus Christi Urban Airshed
DDM	Decoupled Direct Method
EPA	US Environmental Protection Agency
EPS3	Emission Processing System version 3
MM5	Mesoscale Meteorological Model
NAAQS	National Ambient Air Quality Standards
NNA	Near Nonattainment Area
NO_x	Oxides of Nitrogen
NRS	New Source Review
O_3	Ozone
POCC	Port of Corpus Christi
ppb	parts per billion
tpy	tons per year
TCEQ	Texas Commission on Environmental Quality
VOC	Volatile Organic Compounds

1. EXECUTIVE SUMMARY

The City of Corpus Christi is currently designated as an Ozone Near Non-Attainment Area by the Texas Commission on Environmental Quality (TCEQ) based on the 8-hour National Ambient Air Quality Standard (NAAQS) for ozone. Corpus Christi urban airshed is comprised of Nueces and San Patricio counties along with portions of Aransas and Kleberg counties. The Port of Corpus Christi (POCC) is located within this urban airshed and it is the sixth largest port in the United States. The Port is home to several terminal operations owned by private entities.

NuStar Logistics, LP (NuStar) owns and operates the Corpus Christi Terminal located in Nueces County. This facility receives, stores, and transfers petroleum products and chemicals. The terminal consists of marine loading/unloading operations, various storage tanks and their associated piping, and pertinent control equipment. This facility is currently operating under New Source Review (NSR) Permit No. 32769. NuStar recently submitted a permit amendment application on May 27, 2011, that requests the authorization to load up to 200,000 bbl/day of crude oil and condensate at two of its docks.

While storing and during loading/unloading onto barges and ocean going vessels, volatile organic compounds (VOC) gets emitted into the lower atmosphere. VOCs are precursor emissions critical in the formation of ground level ozone as a secondary pollutant. Thus, it is imperative to determine the impact of these new emission sources on the local ozone formation. The primary objective of this study was to evaluate the impact of the emissions from NuStar's facility on the 8-hour averaged ozone concentrations within the Corpus Christi urban area and the surrounding region using a photochemical model.

TECQ recommended regulatory photochemical model Comprehensive Air Quality Model with extensions (CAMx) and other relevant recommended models were employed in this study. CAMx simulates the emission, dispersion, chemical reactions, and removal of pollutants in the lower troposphere by solving the pollutant continuity equation for each chemical species on a system of nested three-dimensional grids (CAMx, 2011). The model was simulated for the high ozone days of September 8-16, 2002 during which high ozone concentrations were measured in several urban areas of Texas including Corpus Christi. The emissions inventory used in the model was enhanced using more recent new and proposed sources of emissions including the Las Brisas power plant and the TPCO America Corporation within the urban airshed. The enhanced base case 2002 episode model performance was evaluated and the results were observed to be within the model evaluation limits set by EPA. NuStar's emissions were subsequently added to the enhanced base case model for impact analysis purpose. Theimpact of NuStar's emissions on the 8-hour ozone concentrations within the urban airshed and surrounding region was spatially and temporally analyzed using a zero-out emissions modeling approach. Besides the zero-out analysis, ozone sensitivity to NuStar's emissions was analyzed using the Decoupled Direct Method (DDM). DDM is a probing tool used for local emissions sensitivity analysis technique widely used in three-dimensional air quality models to determine response of ozone to emissions.

Based on the emission estimates calculated for the permit application, the amendment to NuStar Permit No. 32763 will result in a potential increase of approximately 456 tons per year of VOC into the lower atmosphere over the Corpus Christi urban area. The emission rates used in the photochemical model are based on the maximum allowable hourly rates from each source in order to provide a maximum impact scenario for the days modeled. The corresponding annualized rate based on the hourly rates would yield an increase of approximately 1,104 tpy (see Table 1). An impact assessment analysis of NuStar's emission using the photochemical modeling approach revealed a **net impact of less than 1 ppb on the 8-hour ozone concentration**. A spatial analysis of the modeled results showed that the maximum impact on the 8-hour ozone concentration within the urban airshed as a result of the newly introduced emissions from NuStar's operations ranged between **0.10 - 0.18 ppb**. Furthermore, the first order emissions sensitivity coefficient estimated by the DDM analysis revealed that the VOC sensitivity of the urban airshed increases by up to 0.2 ppb as a result of the NuStar emissions. In summary, using the photochemical modeling analysis it was estimated that the VOC emissions from NuStar's facility in Corpus Christi will have a small to marginal impact (less than 1 ppb) on the 8-hour averaged ozone concentrations within the Corpus Christi urban area and surrounding regions.

2. INTRODUCTION

The City of Corpus Christi is currently designated as an Ozone Near Non-Attainment Area by the Texas Commission on Environmental Quality (TCEQ) based on the 8-hour National Ambient Air Quality Standard (NAAQS) for ozone. The Port of Corpus Christi (POCC) located in this urban airshed is the sixth largest port in United States. NuStar Logistics, LP's (NuStar) Corpus Christi Terminal is situated within the Port premises. Figure 1 shows the location of this facility adjacent to the Corpus Christi ship channel.

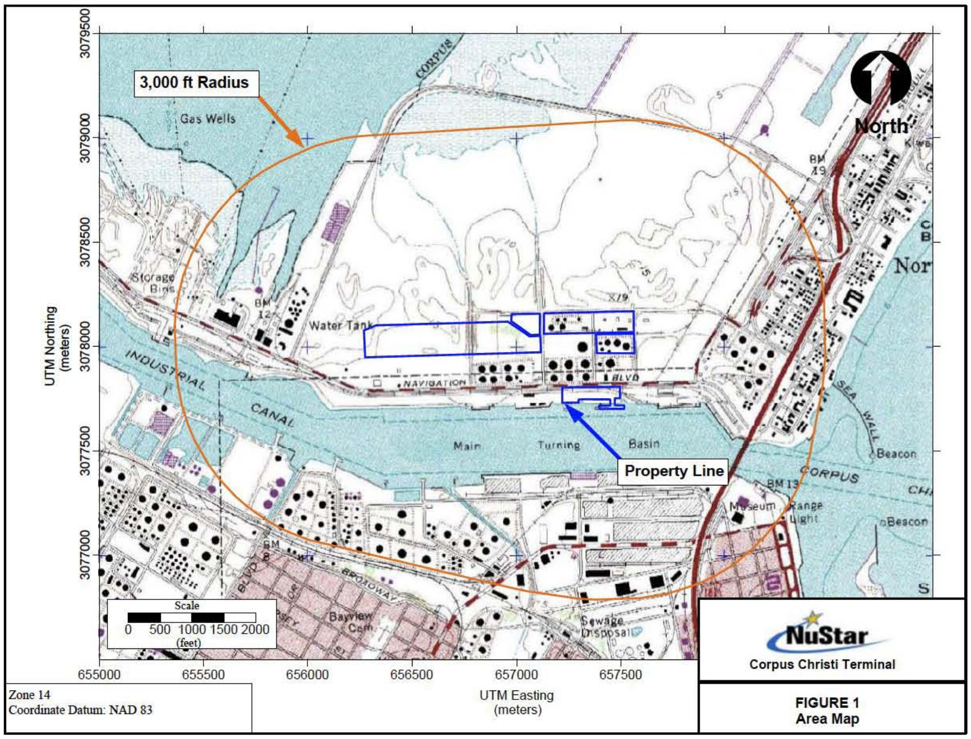


Figure 1. NuStar's Corpus Christi Terminal at the Port of Corpus Christi. (*Source: RPS Group, Austin, TX*)

On May 27, 2011, NuStar submitted an application to amend the New Source Review Permit No. 32769 to store crude oil produced from the Eagle Ford Shale formation in South Texas and subsequently load it into marine vessels. The purpose of this facility is to locally store and subsequently load crude oil from the Eagle Ford shale gas operations onto ocean going vessels. Crude oil and condensate from the Eagle Ford Shale production fields in Central Texas will be pumped via pipeline into one of the four existing 400,000 barrel internal floating roof tanks (Tanks 400M1 through 4) as shown in Figure 1 above. The crude oil and condensate will be pumped from the storage tanks through a pipeline to the Port of Corpus Christi Oil Docks No. 1 and 2 operated by NuStar. Oil Dock No. 1 is designed to receive both barges and ships, while Oil Dock No. 2 can only handles barges. The storage tanks will also be used to store crude oil brought to the terminal by marine vessels. Vapors from marine loading will be routed through an existing vapor collection system with a minimum collection efficiency of 95% and subsequently to an existing vapor combustion unit (VCU) with a minimum destruction efficiency of 99%.

During the operation at the facility, volatile organic compounds (VOC) emission will be emitted into the lower atmosphere, and VOCs as a precursor emission aid in the formation of ground level ozone. The maximum amount of ozone precursor emissions emitted at this facility was calculated and reported as part of the permit application process and these are shown in Table 1. It is imperative to determine the impact of these new sources along with the existing local emission sources on ozone formation within the urban airshed. Thus, the primary objective of this study is to evaluate the impact of the emissions from NuStar's facility on the 8-hour averaged ozone concentrations within the Corpus Christi urban area and the surrounding region using a photochemical model.

This report will provide a discussion on impact assessment of NuStar's emissions to the urban 8-hour ozone concentrations using a comprehensive air quality modeling approach. This was accomplished by employing a photochemical modeling framework that includes emissions processing, meteorological modeling and photochemical model simulations of a high ozone episode affecting the study region. The national emission inventory (NEI) for the year 2002 was used in this study as a baseline while specific emissions within the Corpus Christi urban airshed were enhanced such as the non-road source categories using local activity data. Biogenic emissions were estimated using GloBEIS model. Pennsylvania State University's mesoscale meteorological model, MM5, was used to generate the parameters describing atmospheric physics and the Comprehensive Air Quality Model with extensions (CAMx) version 5.40 was used as the photochemical model. The analysis of the impact of NuStar emissions was accomplished through 'zero-out' emissions modeling and via a detailed ozone sensitivity analysis. The spatial and temporal impact of NuStar's emission was estimated using the zero-out approach. Furthermore, the analysis of the sensitivity of ozone to emissions was conducted using a probing decoupled direct method (DDM) technique. The results from these analyses are presented in this report.

The report is organized as shown below -

- Section 1: Provides an executive summary of the project.
- Section 2: Introduction
- Section 3: Describes project goals and objectives.
- Section 4: The base case photochemical modeling is discussed.
- Section 5: Provides in detail the impact assessment of NuStar's emission to the Corpus Christi urban 8-hour ozone concentrations.
- Section 6: This section summarizes the findings from this study.

Table 1. Emissions summary from NuStar's Corpus Christi Terminal

EPN	Name of the model	Description	East Meters	North Meters	Base Elevation Ft	Release Height Ft	VOC[a] lb/hr	VOC[b] ton/year	Diameter Ft	Velocity Ft/Sec	Temperature °F	Length Ft	Width Ft	Axis Degree
S-400M1	400M1	Storage Tank 400M-1	656,913	3,078,043	9.4	50	20.38	89.26	0.0033	0.0033	Ambient	-	-	-
S-400M2	400M2	Storage Tank 400M-2	656,722	3,078,036	14.3	50	20.38	89.26	0.0033	0.0033	Ambient	-	-	-
S-400M3	400M3	Storage Tank 400M-3	656,533	3,078,032	13.0	50	20.38	89.26	0.0033	0.0033	Ambient	-	-	-
S-400M4	400M4	Storage Tank 400M-4	656,341	3,078,027	9.4	50	20.38	89.26	0.0033	0.0033	Ambient	-	-	-
VCU-2	VCU2	Vapor Combustor	657,407	3,077,761	3.6	55	27.01	118.30	11	47	1400	-	-	-
F-2	FUG2	Piping Fugitive	657,294	3,077,756	7.4	3	1.03	4.51	-	-	-	500	50	90
B-1	B1	Oil Dock 1	657,456	3,077,690	0.0	20	71.30	312.29	-	-	-	340	50	90
B-2	B2	Oil Dock 2	657,266	3,077,729	0.0	20	71.30	312.29	-	-	-	340	50	0

Notes:

a=reported hourly VOC emissions from RPS Group, Austin, TX.

b=quantified annual VOC emissions (tpy) used for photochemical modeling analysis and different to permit allowable rates

$$=\frac{VOC\left(\frac{lb}{hr}\right)X24(hr)X365\left(\frac{days}{year}\right)}{2000\ \left(\frac{lb}{ton}\right)}$$

Source: RPS Group, Austin, TX

3. PROJECT GOALS AND TASKS

The primary goal of this study was to evaluate the impact of emissions from NuStar's facility on the 8-hour ozone concentrations within the Corpus Christi urban airshed. This was accomplished using a photochemical modeling framework that included CAMx, MM5 and EPS3 as the numerical and computational tools used in this exercise. The project activities were broken down into the following tasks –

1. Use the CAMx/MM5/EPS3 modeling framework to simulate a high ozone episode of September 2002.
2. Update the photochemical model to use the most advanced and up to date carbon bond chemical mechanism CB6 for analysis.
3. Develop an enhanced base case photochemical model by adding Las Brisas Power plant and TPCO emissions to the existing 2002 base year emissions.
4. Prepare model-ready files using NuStar's point and area source emissions.
5. Conduct a control case simulation using CAMx with NuStar's emissions.
6. Evaluate the impact of NuStar's emissions by contrasting with the enhanced base case simulation.
7. Conduct quality assurance and quality checks on all runs and evaluate emissions.
8. Conduct NuStar's emissions sensitivity to 8-hour ozone formation using Decoupled Direct Method.
9. Develop a detailed report on the impact of NuStar's emissions on urban and regional ozone levels in the Corpus Christi urban airshed.

4. BASE CASE PHOTOCHEMICAL MODELING

4.1. Model Description

Comprehensive Air Quality Model with extensions (CAMx) version 5.40 was employed in this study as the photochemical model to evaluate the impact of emissions on ozone air quality within the urban airshed. CAMx simulates the emission, dispersion, chemical reactions, and removal of pollutants in the lower troposphere by solving the pollutant continuity equation for each chemical species on a system of nested three-dimensional grids (CAMx, 2011). The most advanced and up to date version 6 of carbon bond chemical mechanism was used for the base case development and analysis purposes. The model was simulated for the high ozone days of September 8 - 16, 2002 during which very high ozone levels were measured in several urban areas of Texas. The 2002 episode model performance was evaluated and the results were observed to be within the limits set by EPA model evaluation. A detailed report on this photochemical episode in 2002, development of the modeling framework for base case simulation using an earlier version of CAMx and CB4 chemical mechanism, and the corresponding model performance evaluation was performed and highlighted by Farooqui (Farooqui, 2008). The new base case emissions were enhanced for this study by adding emissions from new and proposed sources including the Las Brisas power plant (John et al.,

2008) and TPCO America Corporation. Tables 2 and 3 shows the summary of emissions from the Las Brisas power plant and TPCO America Corporation.

Table 2. Summary of Las Brisas power plant emissions

NOx (tpy)	VOC (tpy)	CO (tpy)	SO_2 (tpy)
3,824	283	8,154	10,480

Table 3. Summary of TPCO America Corporation's emissions.

S. No.	Emission Point*	LCP Coordinates		Emission Point Discharge Parameters				Emissions		
	EPN	X	Y	Height (m)	Diameter (m)	Velocity (m/s)	Temperature (K)	NOx (tpy)	CO (tpy)	VOC (tpy)
1	EBS	270.7735	-1320.4850	44.99	6.61	16.00	352.83	137.24	1,829.82	137.24
2	RHFS	270.4598	-1320.8800	80.01	3.20	5.24	603.00	67.91	55.93	3.66
3	MPFS	270.4650	-1320.8770	34.99	1.01	6.49	423.00	5.83	4.90	0.32
4	QFS	270.7161	-1320.7550	55.02	1.40	3.81	523.00	11.89	9.99	0.65
5	TFS	270.7431	-1320.7700	55.02	1.31	3.81	473.00	9.51	7.99	0.52
6	VDBS	270.6979	-1320.5570	29.99	8.99	8.81	393.00	7.58	6.37	0.42
7	SMWV	270.6824	-1320.6350	29.69	-	-	Ambient	29.04	30.02	4.01
8	PCLWV	270.6443	-1321.0490	29.99	-	-	Ambient	-	5.22	3.86
9	HRPPWV	270.4303	-1320.9930	29.99	-	-	Ambient	-	6.21	12.46
10	SMWTF	270.6732	-1320.4080	4.30	-	-	Ambient	-	-	0.10
11	RSWTF	270.7907	-1320.9900	3.41	-	-	Ambient	-	-	0.10
12	GWTF	270.4578	-1320.8650	7.99	-	-	Ambient	-	-	0.10
13	CMSCS1	270.6392	-1320.5870	36.00	1.19	32.00	332.83	0.55	1.75	0.07
14	CMSCS2	270.6560	-1320.5940	36.00	1.19	32.00	332.83	0.55	1.75	0.07
15	CS1	270.6714	-1321.0450	24.99	1.01	2.01	Ambient	-	-	0.82
16	CS2	270.5880	-1321.1100	24.99	1.01	2.01	Ambient	-	-	0.82
17	CS3	270.5639	-1321.1570	24.99	1.01	2.01	Ambient	-	-	0.82
18	UVCS	270.7197	-1320.9520	24.99	0.61	7.89	Ambient	-	-	0.01
19	VDSS	270.6934	-1320.5800	39.99	0.79	8.81	503.00	2.19	87.43	0.26
Total								272.29	2,047.38	166.31

*EBS: EAF Baghouse Stack; RHFS: Rotary Hearth Furnace; MPFS: Mandrel Preheat Furnace Stack; QFS: Quench Firnace Stack; TFS: Tempering furnace Stack; VDBS: VD Boiler Stack; SMWV: Steel Making Workshop Vent; PCLWV: premium Connecting Line Workshop Vent; HRPPWV: Hot Rolling and Pipe Processing Workshop Vent; SMWTF: Steel Making Water Treatment Facility; RSWTF: Rolling Steel Water Treatment Facility; GWTF: Graphite Water Treatment Facility; CMSCS: Caster Spray Chamber Stack; CS: Coating Stack; UVCS: UV Coating Stack; VDSS: VD Steam Stack

Source: TCEQ, Austin, TX. (Permit Numbers PSDTX1188 and 86860)

The photochemical modeling domain for the September 8 - 16, 2002 high ozone episode was established using Lambert Conformal Projection (LCP) with nested grid of 36, 12 and 4 km as shown in Figure 2. Emissions were processed for two domains as described below:

1. Regional Domain: The regional emissions grid has 135 x 138 cells of 12 km resolution which covers 36 km domain as shown in Figure 2. Emissions for 12 km domain were extracted by "windowing out" from regional grid of 12 km resolution. Emissions for 36 km domain were generated by aggregating 3 x 3 12 km cell to one 36 km cell over the entire area as shown in Figure 2.
2. NNA Domain: The NNA grid has 90 x 108 cells at 4 km resolution that covers San Antonio, Austin, Victoria and Corpus Christi urban areas.
3. Vertical layers: In the vertical, MM5 is configured with 28 levels, with a minimum surface layer depth of ~20 m.

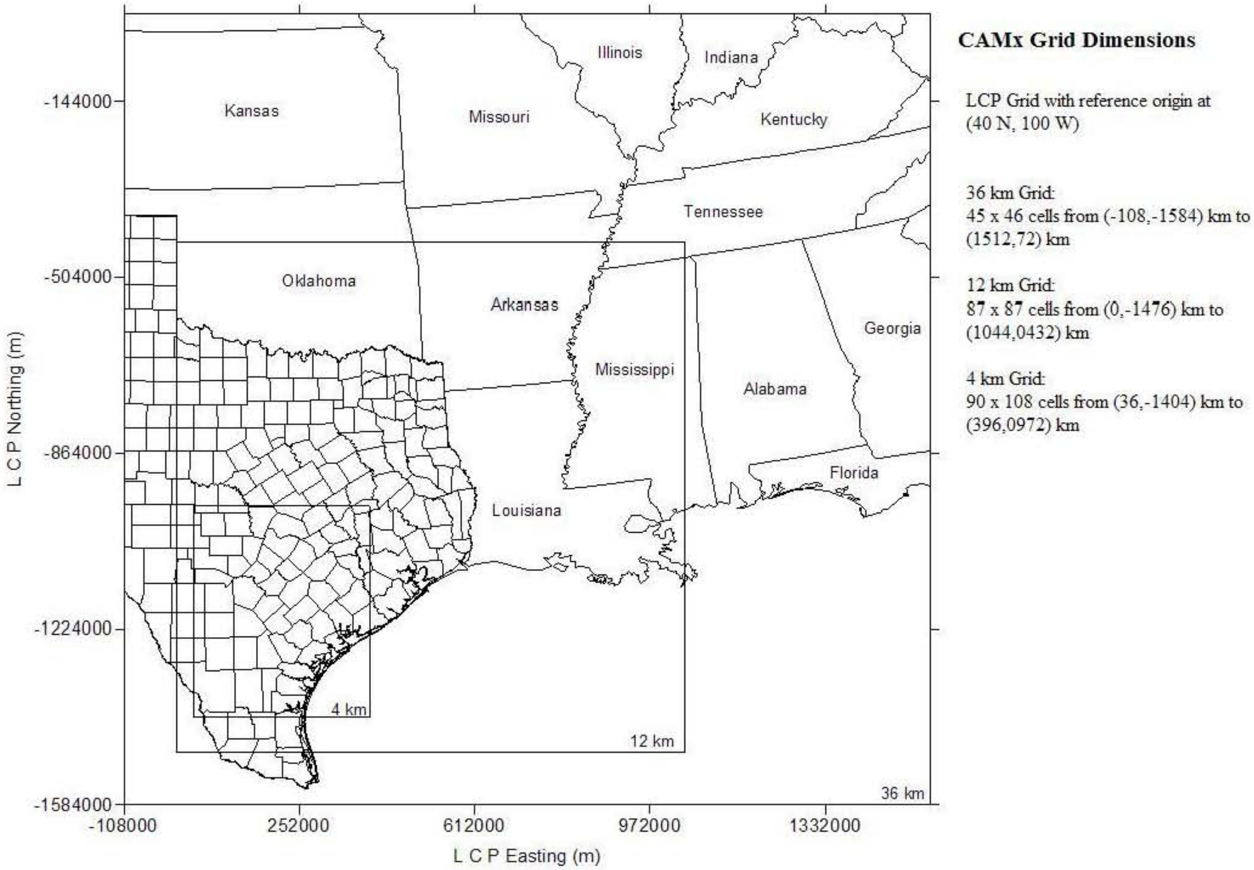


Figure 2. Photochemical modeling domain for the Near Non-attainment Areas of Central and South Texas.

4.2. Model Performance Evaluation

A detailed statistical evaluation of the modeling results followed EPA approved methodology. The following statistical criteria were evaluated for the base case model simulations.

Unpaired Peak Accuracy

The Unpaired Peak Accuracy (UPPA) is the relative difference in percentile between the observed peak and the estimated peak among all sites within a given distance from the observed peak site at any time. EPA recommends this test and the result should be within ±20%. The formula for UPPA is shown below:

$$\text{UPPA} = 100\frac{(O_u - E_u)}{O_u}$$

where, O_u and E_u are the observed and estimated maximum ozone concentrations (unmatched by time and location).

Average Paired Peak Accuracy

The Average Paired Peak Accuracy (Avg. PPA) is the average value of the relative difference in percentile between the observed peak that is greater than 60 ppb and the estimated peak at each site. Its formula is shown below:

$$\text{Avg. PPA} = 100\frac{(O_l - E_l)}{O_l}$$

where, O_l and E_l are the observed and estimated maximum ozone concentrations at site *l* (unmatched by time).

Peak Timing Bias

The Peak Timing Bias (PTB) is the average value of the difference in hours between the time of the observed peak that is greater than 60 ppb and the time of the estimated peak at each site.

Overall Bias

The Overall Bias (OB) is the average value of the relative difference in percentile between all observed values that are greater than 60 ppb and all estimated values at each site and hour. EPA recommends this test and the result should be within ±15%. The formula for OB is shown below:

$$\text{OB} = 100\left(\frac{1}{N}\right)\sum\frac{(O_{t\,l} - E_{t\,l})}{O_{t\,l}}$$

where, O_{tl} and E_{tl} are the observed and estimated hourly ozone concentrations at site *l* and time *t* for a particular region and day (>60ppb)

Overall Gross Error

The Overall Gross Error (OGE) is the average value of the absolute relative difference in percentile between all observed values that are greater than 60 ppb and all estimated values at each site and hour. EPA recommends this test and the result should be below 35%. Its formula is shown below:

$$\text{OGE} = 100\left(\frac{1}{N}\right)\sum\frac{|O_{t\,l} - E_{t\,l}|}{O_{t\,l}}$$

where, O_{tl} and E_{tl} are the observed and estimated hourly ozone concentrations at site *l* and time *t* for a particular region and day (>60ppb)

The archived surface observed ozone data was obtained from TCEQ at urban monitoring sites located within the study region. Table 2 highlights a list of ozone monitoring sites within each ozone near non attainment area with details of their name, EPA site number, and geographic coordinates. The base case evaluation was performed only for the high ozone days of September 11-14, 2002. The results of model performance evaluation are shown in Table 3. The unpaired peak accuracy (UPA) which is a percentage difference of peak observed and model predicted ozone values to the observed ozone values, unmatched by time and space for all NNA were within ±20% limits set by EPA except for 2 days in Corpus Christi and Victoria. Both positive and negative unpaired peak accuracy was observed for San Antonio, Austin, Victoria and Corpus Christi and the observed values were within EPA prescribed limits. The peak timing bias (PTB) is the average value of the difference in hours between the time of the observed peak that is greater than 60 ppb and the time of the estimated peak at each site. The timing bias was 3 and 7 hours on the 12th and 13th for Victoria, while Corpus Christi showed a maximum PTB of -9 hour on 14th September. The model captured the diurnal variability of observed ozone concentrations in the coastal region of Corpus Christi and in the inland regions of San Antonio and Austin. Overall, the model performed reasonably well for each of the urban area and this was within the EPA prescribed acceptable norms for performance.

Table 4. List of ozone monitoring sites with geographic location

Area	Monitoring Site	EPA Site Number	Latitude	Longitude
Austin				
	CAMS 03	484530014	30° 21' 16''	-97° 45' 37''
	CAMS 38	484530020	30° 28' 59''	-97° 52' 20''
San Antonio				
	CAMS 23	480290032	29° 30' 54''	-98° 37' 13''
	CAMS 58	480290052	29° 37' 55''	-98° 33' 54''
	CAMS 59	480290059	29° 16' 31''	-98° 18' 42''
Corpus Christi				
	CAMS 04	483550025	27° 45' 55''	-97° 26' 3''
	CAMS 21	483550026	27° 49' 57''	-97° 33' 19''
Victoria				
	CAMS 87	484690003	28° 50' 10''	-97° 0' 20''

The time series of 1-hour ozone comparing model predicted and surface observed 1-hour ozone at monitoring sites (CAMS) in San Antonio, Corpus Christi, Victoria, and Austin are shown in Figures 3 through 6 for the entire simulation period. The overall pattern of diurnal variability in the ozone concentrations was similar between the observation and the base case. For San Antonio area, model predicted 1-hour ozone concentration captured diurnal trends and the peaks for two days at CAMS 23 and CAMS 58 sites as shown in Figure 3. Similarly, for the Austin area, the model performed well capturing the peak levels and followed the pattern as shown in Figure 4. For the Corpus Christi and Victoria areas, the model captured the diurnal trend very well. However, the model slightly under-predicted the peak 1-hour averaged ozone concentrations on the highest ozone days. Despite this, the model predictions were very much within the EPA prescribed bounds for model performance evaluation. Thus, this modeling framework for the 2002 high ozone episode can be used as a reasonable tool to evaluate the impact of new sources within the modeling domain.

Table 5. Model performance evaluation for September 11-14, 2002

	11-Sep	12-Sep	13-Sep	14-Sep
	San Antonio			
UPA, %	12.2	-12.7	-1.2	1.0
APPA, %	5.4	-19.1	3.8	-5.1
PTB, hr	0	0	0	-1
OB, %	5.0	-14.4	7.0	-4.0
OGE, %	8.9	15.4	11.6	1.1
	Austin			
UPA, %	4.5	5.9	11.6	6.1
APPA, %	-7.2	-12.0	1.4	1.5
PTB, hr	0	0	0	-1
OB, %	-6.1	-9.0	1.0	-2.8
OGE, %	10.6	11.1	8.7	9.5
	Victoria			
UPA, %	11.1	20.2	48.1	36.1
APPA, %	-8.1	-10.8	-0.1	-6.7
PTB, hr	-1	3	7	-4
OB, %	-2.3	-4.3	7.4	-10.0
OGE, %	7.2	8.9	8.3	13.6
	Corpus Christi			
UPA, %	37.4	2.6	38.4	8.8
APPA, %	1.8	-16.8	6.7	-46.5
PTB, hr	1	-2	2	-9
OB, %	4.6	-20.3	10.2	-46.0
OGE, %	6.3	20.3	10.4	46.0

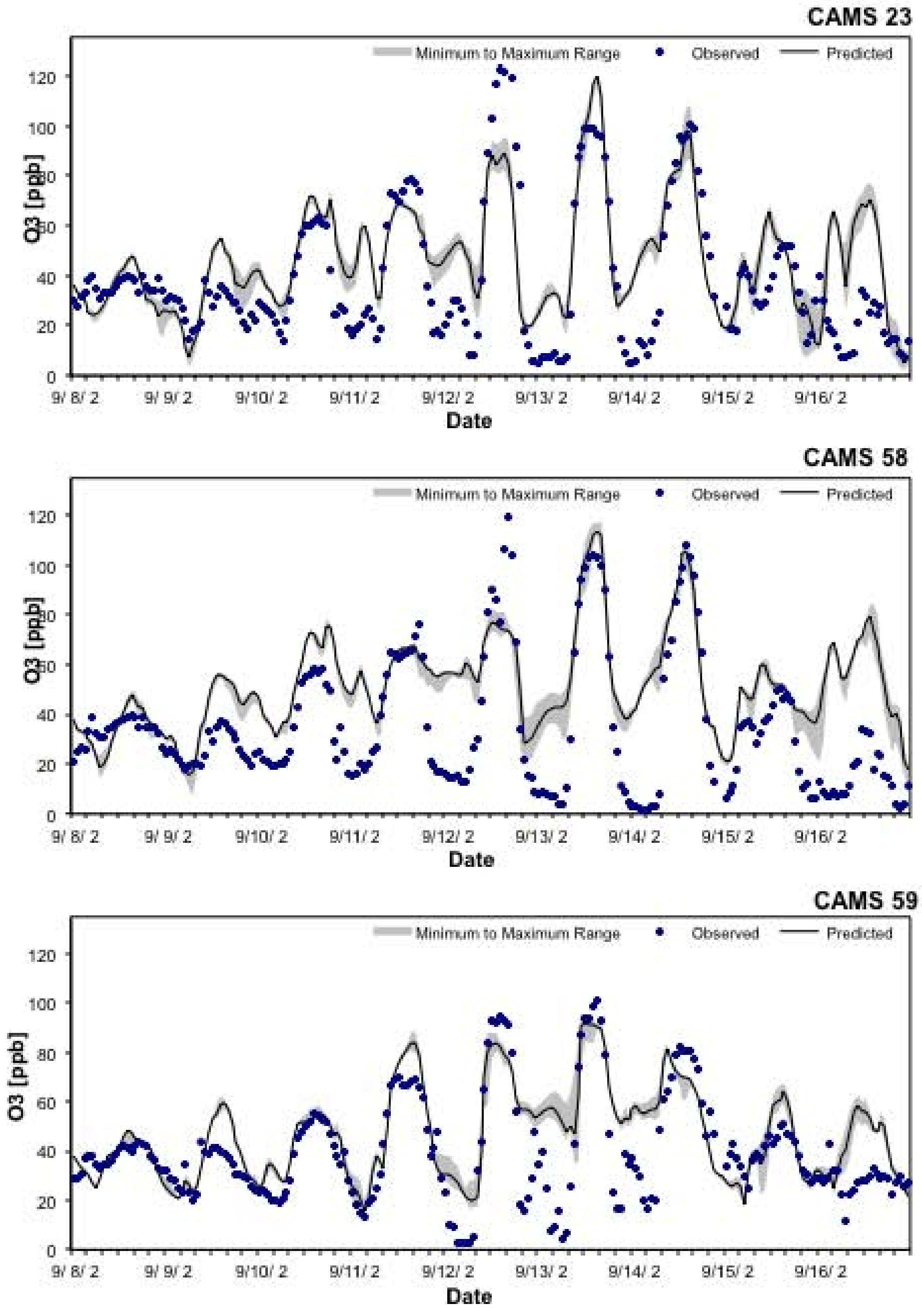


Figure 3. Time series plots of observed and predicted hourly ozone for three monitoring sites (CAMS 23, 58, and 59) in San Antonio (September 8-16, 2002) for the base case run.

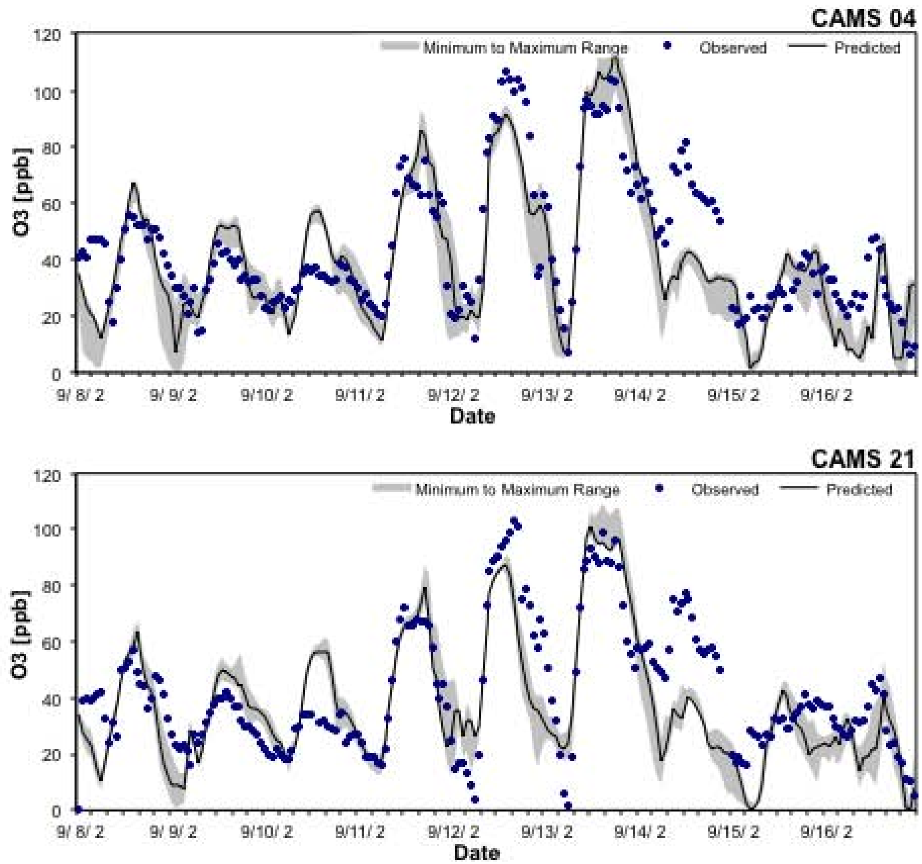


Figure 4. Time series plots of observed and predicted hourly ozone for two monitoring sites (CAMS 04 and 21) in Corpus Christi (September 8-16, 2002) for the base case run.

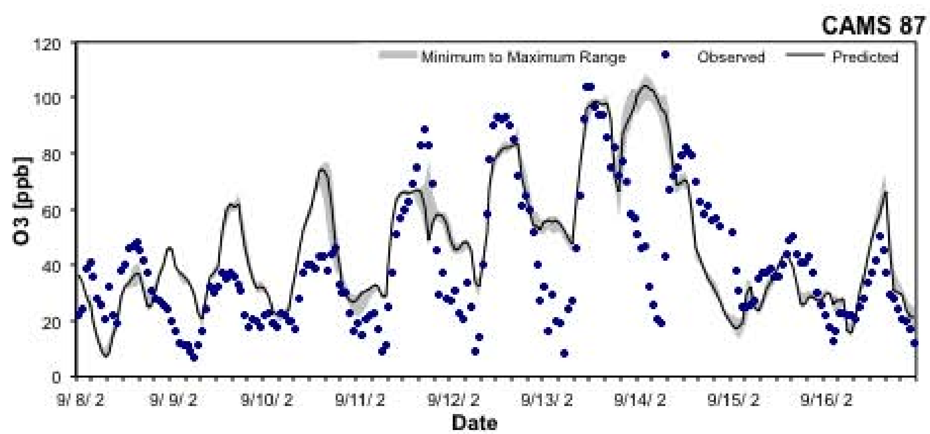


Figure 5. Time series plots of observed and predicted hourly ozone for one monitoring site (CAMS 87) in Victoria (September 8-16, 2002) for the base case run.

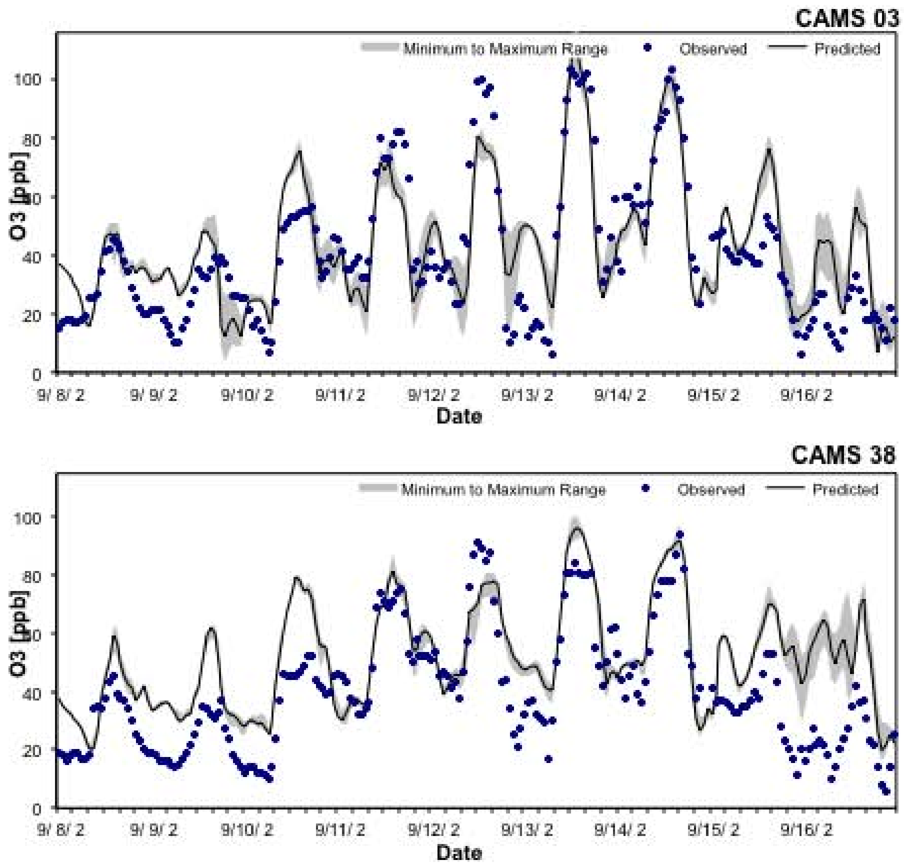


Figure 6.Time series plots of observed and predicted hourly ozone for two monitoring sites (CAMS 03 and38) in Austin (September 8-16, 2002) for the base case run.

5. IMPACT ASSESSMENT OF NEW EMISSION SOURCES

5.1. Peak Ozone Impact

To assess the air quality in the Corpus Christi urban airshed (CCUA), an advanced photochemical model, Comprehensive Air Quality Model with extensions version 5.40 (CAMx) (www.camx.com) with CB6 chemical mechanism (Yarwood et al., 2010) was used along with the Fifth Generation Pennsylvania State University/National Center of Atmospheric Research (PSU/NCAR) Meteorological Model (MM5) for characterizing the meteorological fields and developing the model input files. September 8-16, 2002 high ozone episode was used for this impact assessment study. This episode employed a base case MM5 meteorology and model-ready emissions based on 2002 National Emissions Inventory (NEI) with an enhancement for new and proposed sources by using the permitted emissions from the Las Brisas power plant and TPCO America Corporation within CCUA. The enhanced base case simulation was further modified to incorporate NuStar’s point source and area emissions. The impact on peak ozone levels was calculated by subtracting the modeled peak predicted ozone concentrations of base case run from that of a control case run using equations 1 and 2 as shown below.

Episodic impact of emissions = $MAX\left(O_{3,8\text{-}\,hour,base}\right) - MAX\left(O_{3,8\text{-}\,hour,control}\right)$ (1)

Hourly impact of emissions = $MAX\left(O_{3,8\text{-}hour,base} - O_{3,8\text{-}hour,control}\right)$ (2)

The control case is a photochemical model simulation in which emissions from NuStar's facility were removed. Equations 1 and 2 estimated the maximum spatial difference of the impact on 8-hour ozone un-paired and paired with respect to time, respectively. Figures 7 and 8 shows impact of NuStar's emission on the 8-hour ozone levels within the 4 km photochemical modeling domain and within Corpus Christi urban area using equations 1 and 2. Figure 7(a) shows the maximum spatial impact un-paired with time and Figure 7(b) shows the maximum spatial impact paired with time within the 4 km modeling domain. It was found that the NuStar's emission would add approximately 0.10 and 0.18 ppb to the predicted peak 8-hour ozone concentrations within the urban and surrounding areas. Figures 8(a) and 8(b) (are zoomed in plots) show in detail the spatial impact within the Corpus Christi urban airshed. It was found that the maximum spatial impact on the 8-hour ozone concentrations un-paired with time was about 0.10 ppb in close proximity to the source with a plume direction towards the west-southwest as shown in Figure 8(a). The maximum impact of 0.18 ppb on the 8-hour ozone paired with time was further downwind northwest to the source as shown in Figure 8(b). This would suggest that an overall impact on the predicted 8-hour ozone concentration was in the range between 0.10 within the urban area and 0.18 ppb further downwind and that the overall influence of this new source will be significantly below 1 ppb. Such a small response is primarily driven by the magnitude of the overall emissions from this new source in relative comparison to the overall urban and industrial emissions in the region. An additional consideration is the fact that this region is NOx limited, and any increase/reduction in the urban/industrial NOx emissions will have a relatively bigger impact on the urban ozone levels than similar changes in the VOC emissions.

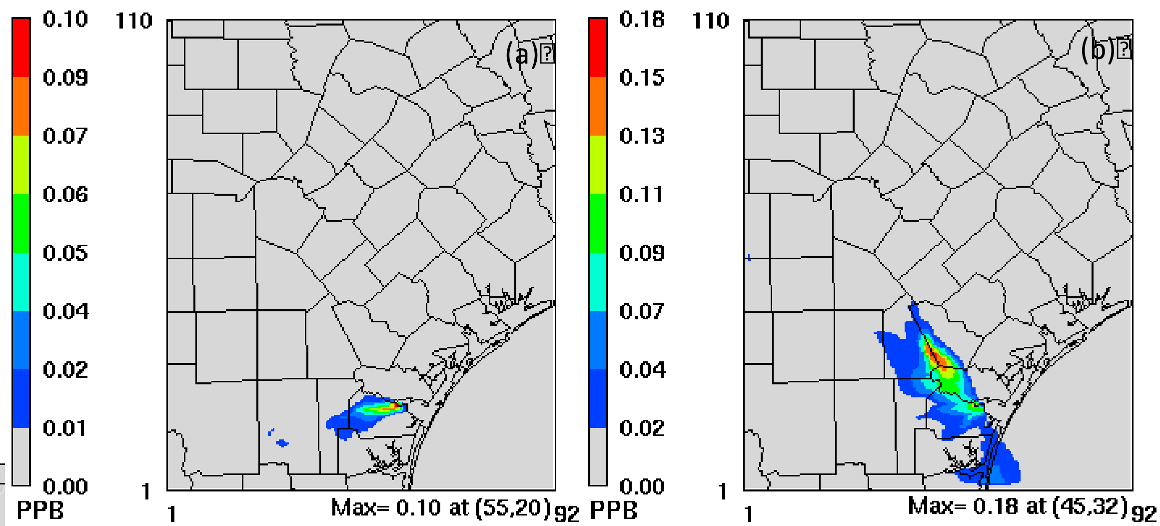
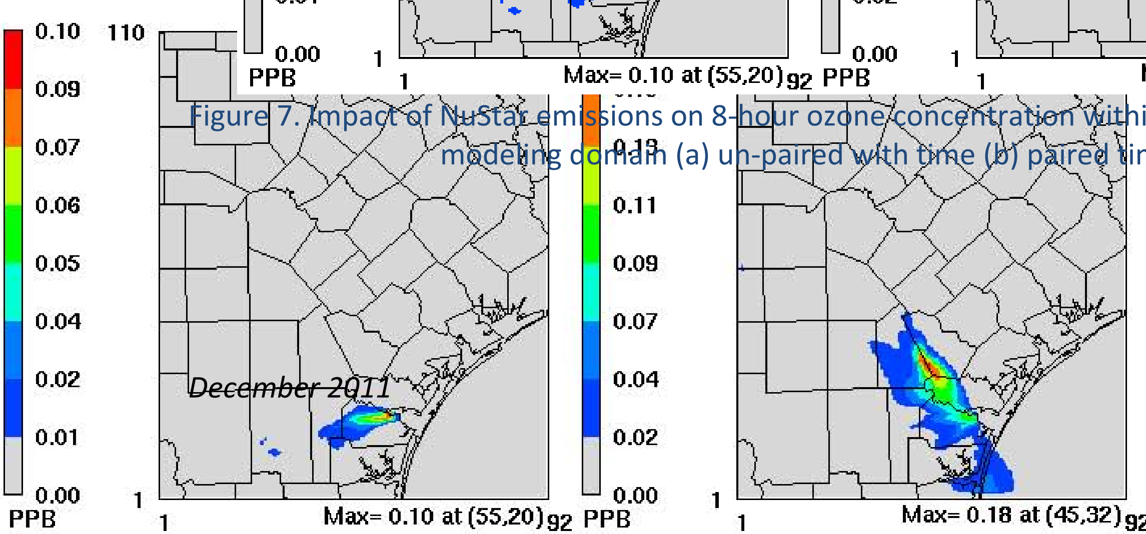


Figure 7. Impact of NuStar emissions on 8-hour ozone concentration within 4 km photochemical modeling domain (a) un-paired with time (b) paired time.



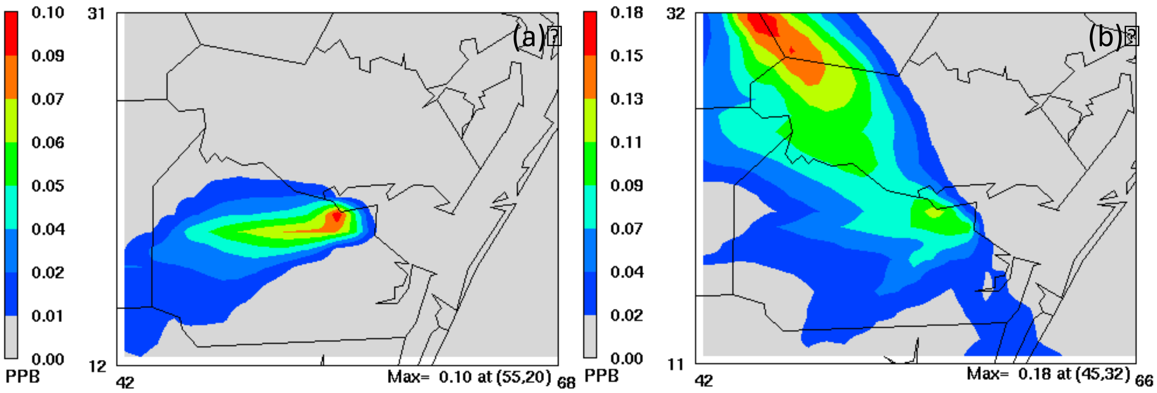


Figure 8. Impact of NuStar emissions on 8-hour ozone concentration within Corpus Christi urban airshed (a) un-paired with time (b) paired time.

5.2. Hourly Ozone Impact

The hourly impact of NuStar's emission was evaluated at the TCEQ compliance monitoring station CAMS 04 and 21. Figure 9 shows the observed and model predicted hourly 8-hour ozone concentration for the enhanced base case (without NuStar's emissions) and control case simulations (with NuStar's emissions). The hourly difference of 8-hour ozone concentration between the control case and the base case is very minimal that both the time-series plots overlap with each other. Figure 10 shows the hourly difference between the 8-hour ozone concentrations from the base case and the control case at CAMS 04 and 21, respectively. The positive difference between the base case and the control case indicates the impact due to NuStar's emission at the site. This is due to a slightly higher 8-hour ozone concentration observed in the base case (with NuStar's emission) than in the control case (without NuStar's emission). It was found that the maximum impact was under 0.1 ppb at each of the compliance monitoring sites within the Corpus Christi urban area. At CAMS 04, the maximum difference of 0.07 ppb was noted for September 11, while at CAMS 21 the maximum difference of 0.08 ppb was observed on September 14. The maximum differences were noticed in the morning and early afternoon hours at each of these sites.

A spatial display of the daytime hourly difference plots of the 8-hour ozone concentrations for September 13 and 14 are shown in Figures 11 and 12. On September 13, the difference plots showed the impact plume oriented towards the east with the maximum difference of 0.08 ppb as shown in Figure 11. The impact area broadly covered most of the urban area during the morning hours (6 – 9 a.m.). As the day winds down, the plume narrows by around noon with a similar directional orientation. After 3 p.m., there was no impact observed in the urban area. But on September 14, due to a change in the wind direction, the difference plume shifted to the northwest direction and it showed a maximum difference of up to 0.18 ppb in the outer domain of the urban airshed as shown in Figure 12. The impact on the 8-hour ozone concentration showed a region beyond San Patricio and Nueces counties within CCUA. Similar to the earlier day, the maximum difference was noted during the morning hours till noon only and the differences then started to narrow down and after 4 p.m. it disappeared. The impact plume was thicker during the morning hours and spatially covered approximately

50% of the San Patricio county. The impact plume started disappearing later during the day and completely vanished after 4 p.m. The episode specific analysis highlights the impact of new sources such as NuStar on the urban and regional air quality under a worse-case ozone episode and provides a rather conservative estimate of the overall impact. Since 2002, CCUA has not experienced any significant ozone episodes of such relative magnitude and the area has shown a decrease in the design value of ozone NAAQS. Thus based on this analysis it can be assumed that the overall impact of NuStar on the urban atmosphere will probably be below 0.18 ppb based on the 8-hour ozone NAAQS.

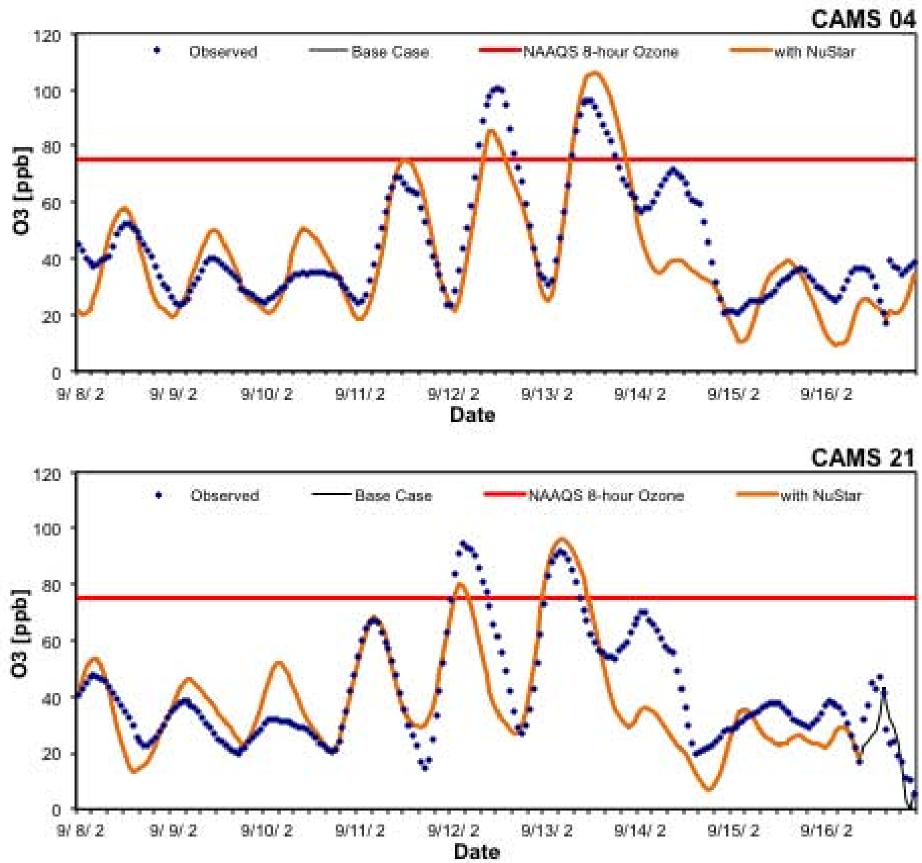


Figure 9. Time series plots of observed and predicted hourly 8-hour ozone for two monitoring sites (CAMS 04 and21) in Corpus Christi urban airshed (September 8-16, 2002) for the base case run and control case (with NuStar emissions).

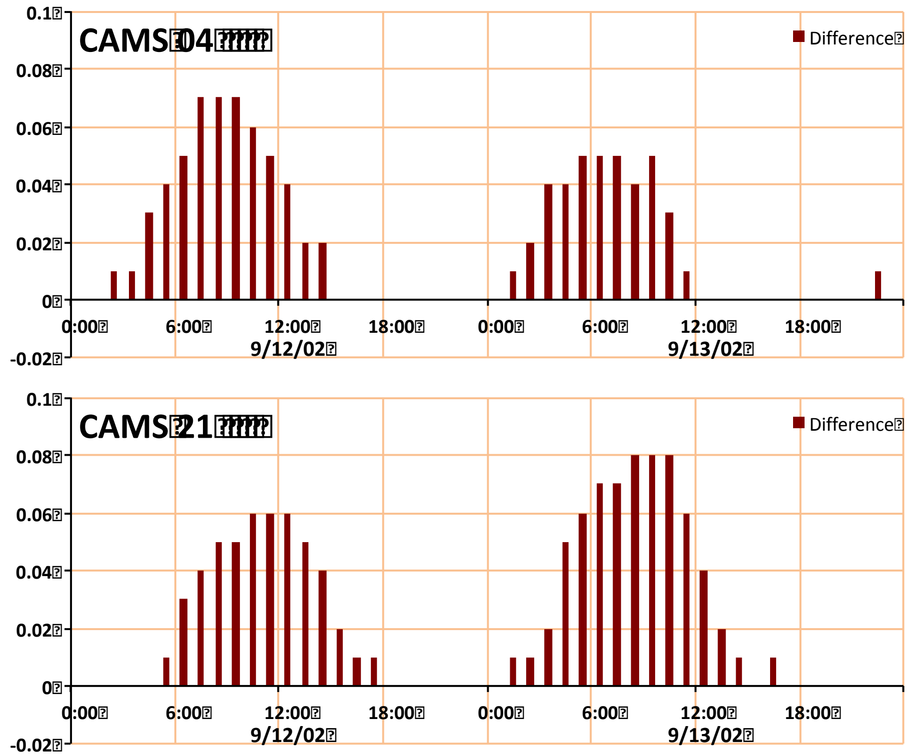


Figure 10. Maximum hourly difference between base case and control case in the predicted 8-hour ozone concentrations at CAMS 04 and 21 in Corpus Christi.

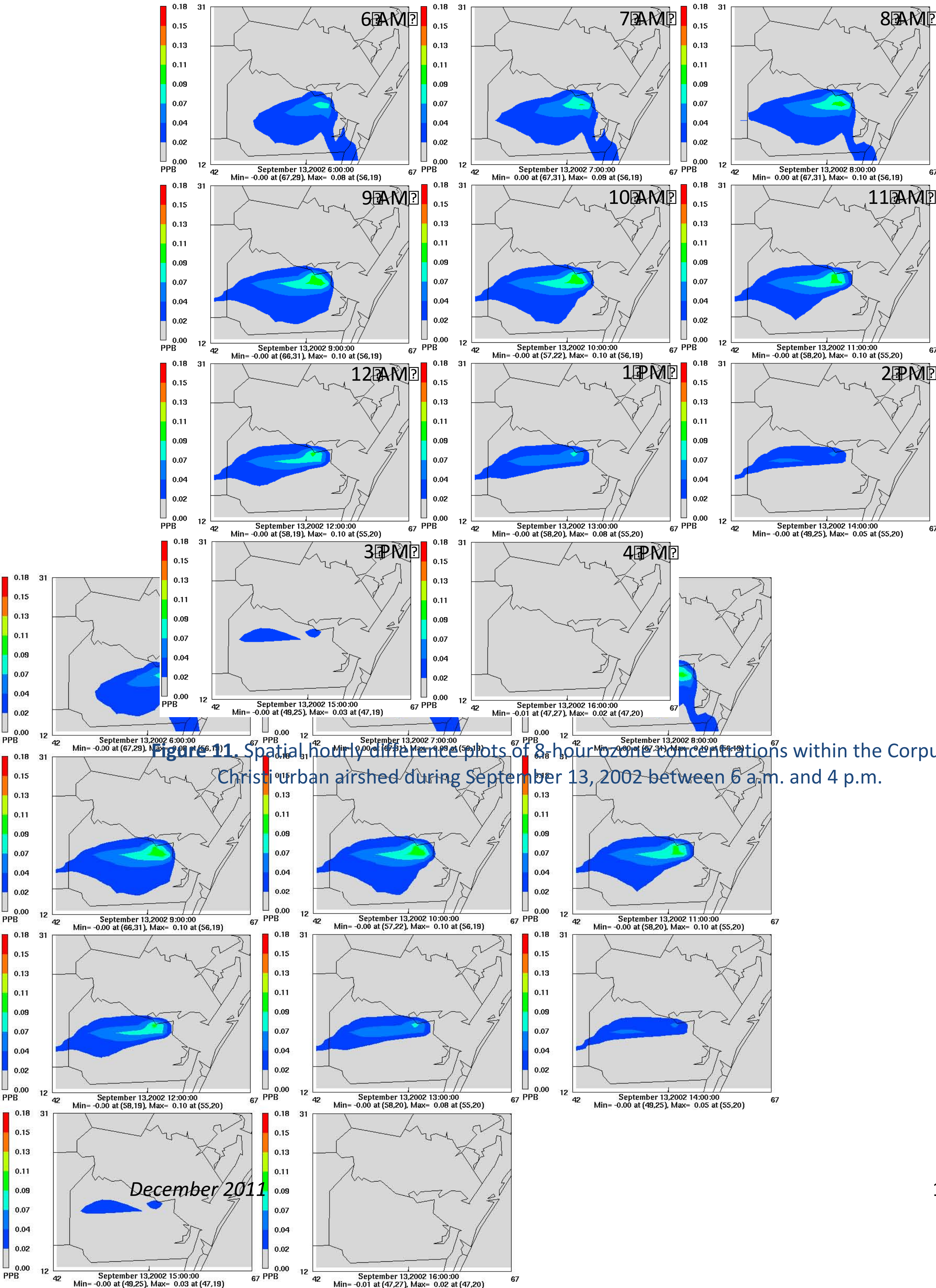


Figure 11. Spatial hourly difference plots of 8-hour ozone concentrations within the Corpus Christi urban airshed during September 13, 2002 between 6 a.m. and 4 p.m.

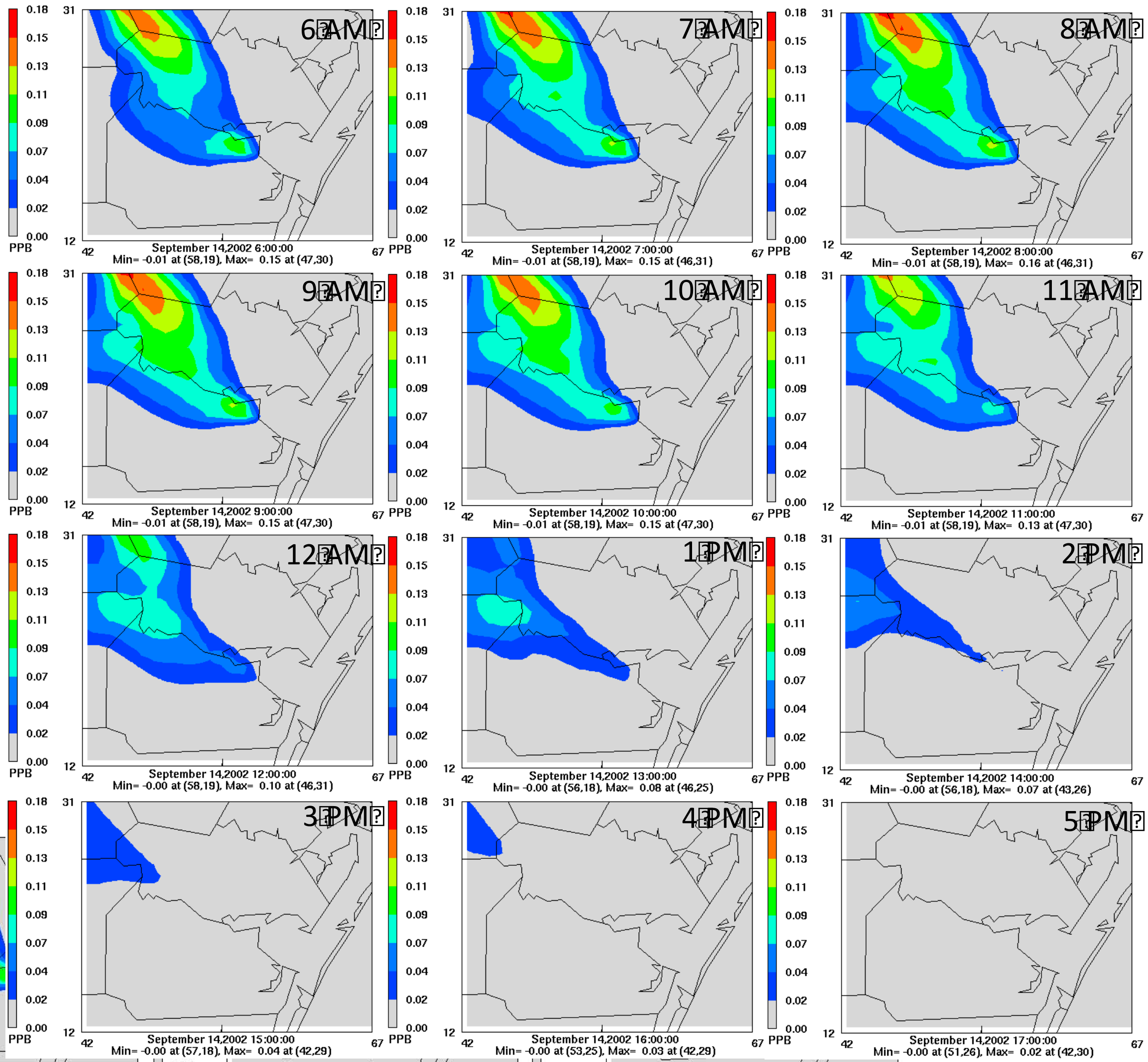


Figure 12. Spatial hourly difference plots of 8-hour ozone concentrations within the Corpus Christi urban airshed during September 14, 2002 between 6 a.m. and 5 p.m.

5.3. Emissions Sensitivity Coefficient Assessment

The photochemical model was also used to determine ozone sensitivity coefficients due to NuStar's emissions using decoupled direct method (DDM). DDM is a stable and a computationally efficient tool which integrates and evaluates the sensitivity equation, decoupled from the model equations (Hakami, et al., 2003). Due to its efficiency, DDM is a widely used technique in three-dimensional air quality to determine the response of ozone to local emissions (Cohan et al., 2005). First and higher order DDM analysis probing tools in CAMx was used to determine the ozone sensitivity coefficient from NuStar's emissions. This analysis will highlight the response and/or sensitivity of ozone to emissions. From the DDM analysis, the ozone sensitivity coefficients affected by NuStar's VOC emissions were estimated for first and higher order and are spatially shown in Figure 13. Figure 13(a) shows the maximum ozone sensitivity coefficient to NuStar's VOC emissions. It was found that the maximum coefficient was 0.2 ppb around the source and within the urban airshed as shown in Figure 13(a). This indicates that the NuStar 's emission can potentially influence up to 0.2 ppb in ozone formation within the urban airshed. The ozone sensitivity coefficient calculated was slightly higher within Nueces county, while up to 0.08 ppb was found outside of the county towards the east and to the south. A primary maximum ozone sensitivity coefficient was located immediately downwind of the source within Nueces county, while a secondary maximum coefficient was located in Kleberg County, south of the urban airshed as shown in Figure 13(a), based on other flow regimes during the episode. Figure 13(b) shows higher order sensitivity coefficient affected by NuStar's VOC emissions. This coefficient was essentially negligible and its geographic distribution is primarily very close to the source of VOC emissions. This will be an important parameter if there were co-located sources of significant NOx from NuStar's facility or other major sources in close proximity.

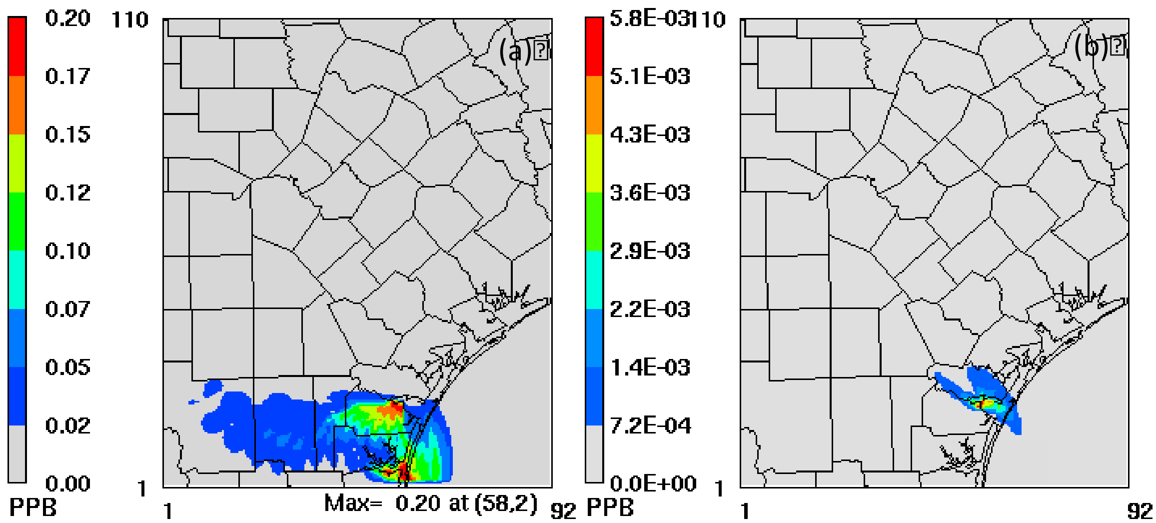
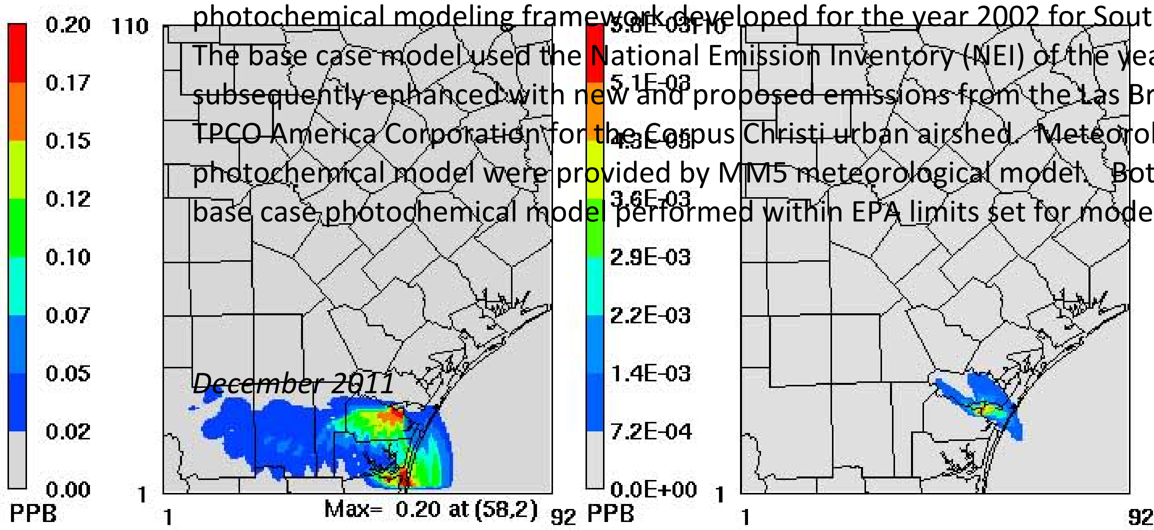


Figure 13. Maximum spatial (a) first and (b) higher order ozone sensitivity coefficients of NuStar's VOC emissions within Corpus Christi urban airshed.

6. SUMMARY FINDINGS

A comprehensive assessment of the impact of NuStar's Corpus Christi terminal operations on the urban 8-hour ozone concentrations was conducted using a base case photochemical modeling framework developed for the year 2002 for South and Central Texas. The base case model used the National Emission Inventory (NEI) of the year 2002 and subsequently enhanced with new and proposed emissions from the Las Brias power plant and TPCO America Corporation for the Corpus Christi urban airshed. Meteorological inputs to the photochemical model were provided by MM5 meteorological model. Both meteorological and base case photochemical model performed within EPA limits set for model evaluation.



Based on the emission estimates calculated for the permit application, the amendment to NuStar Permit No. 32763 will result in a potential increase of approximately 456 tons per year of VOC into the lower atmosphere over the Corpus Christi urban area. The emission rates used in the photochemical model are based on the maximum allowable hourly rates from each source in order to provide a maximum impact scenario for the days modeled. The corresponding annualized rate based on the hourly rates would yield an increase of approximately 1,104 tpy. An impact assessment analysis of NuStar's emission using the photochemical modeling approach revealed a **net impact of less than 1 ppb on the 8-hour ozone concentration**. A spatial analysis of the modeled results showed that the maximum impact on the 8-hour ozone concentration within the urban airshed as a result of the newly introduced emissions from NuStar's operations ranged between **0.10 - 0.18 ppb**. Furthermore, the first order emissions sensitivity coefficient estimated by the DDM analysis revealed that the VOC sensitivity of the urban airshed increases by up to 0.2 ppb as a result of the NuStar emissions. In summary, using the photochemical modeling analysis it was estimated that the VOC emissions from NuStar's facility in Corpus Christi will have a small to marginal impact (less than 1 ppb) on the 8-hour averaged ozone concentrations within the Corpus Christi urban area and surrounding regions.

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